Augmentation of Sensorimotor Adaptability Using Stochastic Resonance Technologies

Completed Technology Project (2013 - 2017)

Project Introduction

Astronauts experience sensorimotor dysfunction during adaption to g-transitions that occur when entering and exiting microgravity. These sensorimotor disturbances can include postural and gait instability, visual performance changes, manual control disruptions, spatial disorientation, and motion sickness. In an emergency situation on Earth or on an extraterrestrial surface, crewmembers adapted to being in microgravity may need to egress the vehicle immediately after landing. Sensorimotor dysfunction associated with the inability to quickly adapt could cause performance to degrade in critical tasks such as visual monitoring of displays, actuation of controls, operation of reserve equipment, and communication between crewmembers and mission control. Similar performance degradation could also hinder a crewmember's ability to safely land their spacecraft or to traverse a planetary surface during an EVA. Crewmember safety would be significantly increased if they could more easily adapt to changes in the gravitational environment. The goal of this research is to investigate and develop the use of stochastic resonance technologies as a countermeasure to augment sensorimotor function and adaptation. Stochastic resonance (SR) is a phenomenon in which the response of a non-linear system to a weak input signal is optimized by the presence of a particular non-zero level of noise. SR improves function by enhancing the transfer of information to the system. It has been shown that the coupling of stochastic noise at imperceptible levels with sensory input can improve motor, cardiovascular, visual, hearing, and balance function. Applying SR to the vestibular system has been shown to improve ocular stabilization reflexes, postural balance during walking and standing, and perception in sensory conflict scenarios. We hypothesize that SR quickens strategic learning and consequently the rate of early adaptation. Long-term sensorimotor adaptation, which has been shown to correlate with early recovery, should also be quicker with SR, improving overall safety and performance of astronauts immediately post-landing and long-term. Vestibular SR is implemented by applying a stochastic electric stimulation signal to the vestibular system via electrodes placed over the mastoid processes. To maximize augmentation, the subject specific optimal SR levels will be implemented. The specific aims of this research are as follows: Develop, test, and verify an algorithm to efficiently determine an individuals optimal SR level using their perceived tilt while on a variable radius centrifuge that induces a roll-tilt sensation. Test the ability of SR to quicken sensory adaptation by analyzing changes in vestibular ocular reflex gain during a novel whole body sinusoidal rotation test paradigm. Test the utility of the optimized SR in a functional task that measures piloting performance during induced tilt illusions associated with landing a vehicle after extended time in space. This research will directly contribute to the development of a future spaceflight countermeasure to improve sensorimotor adaptation during gravitational transitions. This countermeasure could be critically important to crew safety during emergency situations after transitioning out of microgravity. Crewmembers may also use a vestibular SR device during training to improve

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

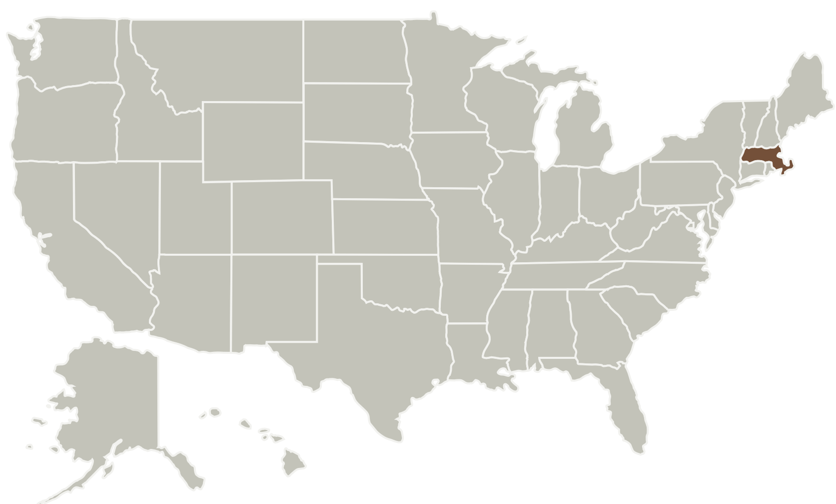
Space Technology Research Grants

skill acquisition or to quicken training adaptability. People with balance or locomotion problems due to aging or disease could also benefit from a sensorimotor augmentation device. For this group, SR technology may significantly improve their overall safety and quality of life.

Anticipated Benefits

This research will directly contribute to the development of a future spaceflight countermeasure to improve sensorimotor adaptation during gravitational transitions. This countermeasure could be critically important to crew safety during emergency situations after transitioning out of microgravity. Crewmembers may also use a vestibular Stochastic resonance (SR) device during training to improve skill acquisition or to quicken training adaptability. People with balance or locomotion problems due to aging or disease could also benefit from a sensorimotor augmentation device. For this group, SR technology may significantly improve their overall safety and quality of life.

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations
Massachusetts

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

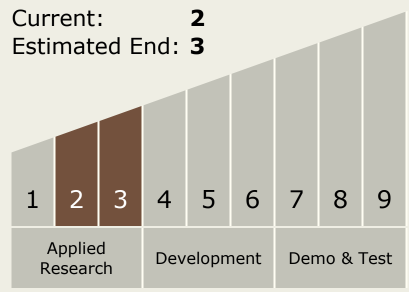
Charles W Oman

Co-Investigator:

Raquel Galvan

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  └ TX12.5 Structural Dynamics
    └ TX12.5.2 Vibroacoustics